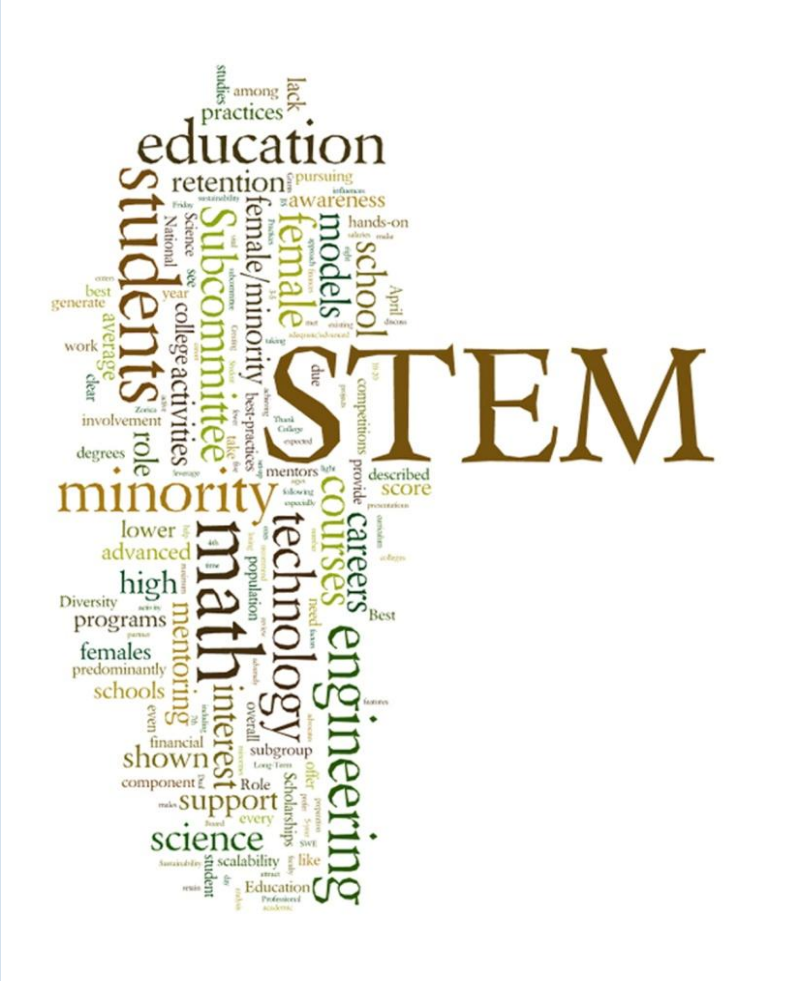
Report of the Diversity Subcommittee

Governor's Science, Technology, Engineering & Mathematics (STEM) Advisory Council



Lieutenant Governor Timothy P. Murray, Chairman

June 2010

Mission of the Diversity Subcommittee

From our analysis of data and indicators on educational achievement, attainment and workforce trends, the Diversity Subcommittee will identify four strategic themes which will guide and inform our work. These themes focus on closing the gap for underrepresented groups, particularly women and minorities. It is the intent of the Diversity Subcommittee that these strategic priorities will be included in the Council's five-year plan for improving STEM education.

From our review of local, national and international programs, the Subcommittee will identify best practices that lead underrepresented groups to engage in STEM education and enrichment, achieve at high levels on a variety of state and national assessments, and pursue postsecondary degrees and careers in STEM-related fields. We will also consider the roles of stereotypes, role models, internships and industry collaborations and the potential impact of these on individuals' entrance into -- and persistence within -- the STEM pipeline. Our final report will explore current initiatives - and make the case for future initiatives - that demonstrate effective collaboration among K-12 and higher education, industry and the non-profit community.

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Message from the Co-Chairs

June 30, 2010

On behalf of the Diversity Subcommittee of Governor Deval Patrick's Science, Technology, Engineering and Mathematics (STEM) Advisory Council, we are proud to deliver the report and findings that have been compiled in this strategic and critically important area related to diversity, STEM education and the workforce.

As co-chairs, we want to thank all members of our committee for their contributions and dedication for making diversity and STEM education a priority for the Commonwealth of Massachusetts. The collaboration among the members of the subcommittee and others who have supported this initiative has been paramount to the successful completion of our findings.

A special thanks goes to Marissa Goldberg Cole, Deputy Chief of Staff, Massachusetts Executive Office of Education for her tremendous effort and talent that she provided in support of the committee from research and editing to keeping everybody on track and schedule. We also want to extend thanks to Erin Bradley, Chief of Staff at Girl Scouts of Eastern Massachusetts and Jamie Kelly, Director of Public Affairs, Wentworth Institute of Technology.

Over the past three months, the full committee has formally met three times to identify and address the following major areas of focus for the report: collaboration and partnerships; existing and proven best practices in Massachusetts; and national and international models, programs and best practices. Three working groups were formed to research and analyze these key areas, and the working groups participated in three conference calls as well as in-person meetings and individual work. These meetings and dialogues have been thought-provoking and led to a valuable exchange of ideas for how to strategically approach closing the gap in STEM education and careers for women and underrepresented groups.

This report frames the issues in a meaningful way and presents a clear strategy to address awareness and access to STEM education for these groups as well as focusing on the potential of the underrepresented population of young women and minorities as a key pipeline of workers in the emerging STEM industries.

In conclusion, we want to thank Governor Patrick and Lieutenant Governor Timothy Murray, who served as chairman of the STEM Advisory Council, for their support and focus on STEM as we look to inspire others to pursue personally and professionally rewarding careers in related fields. We are hopeful that these findings, coupled with the Council's five-year plan will lead to proactive steps for assuring the diversity of STEM education and workforce development in Massachusetts and across the country.

Sincerely,

Zorica Pantić, Ph.D.
President, Wentworth Institute of Technology

Ruth N. Bramson
CEO, Girl Scouts of Eastern Massachusetts

Acknowledgements

This report was authored by members of the Diversity Subcommittee of the Governor's Science, Technology, Engineering and Mathematics (STEM) Council.

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Executive Summary

We have a window of opportunity that must not be missed. According to the United States Department of Labor's projections, by 2018, in the science, technology, engineering and mathematics (STEM) fields, jobs will grow 34%, with 2.7 million new jobs being created. The number of qualified candidates for these jobs is projected to increase by only 14% during the same period of time.[i] The nation – and the Commonwealth of Massachusetts - can no longer afford to ignore the potential of our underrepresented populations - girls, young women and minority youth - and the need for them to be part of the pipeline of workers in the emerging STEM industries. Whether one looks at the issues from an economic, political or social justice perspective, these groups are over half of our futures.

The introduction of standards-based reform and corresponding assessments has led to rich data that highlights the strengths and weaknesses of today's students. As showcased in the **Framing the Issue** section of this report, improved collection and analysis of data has provided a humbling picture of the achievement gaps that exist - both here in Massachusetts and nationwide. Research that looks at gender, race, ethnicity, and socioeconomic status reveals critical vulnerabilities among underrepresented groups. The achievement gaps between underrepresented minorities and their white counterparts pervade the STEM fields. While the achievement gap has captured the attention of the education sector in recent years, with educators committed to closing the gap, this is a topic of considerable concern to policymakers, business and industry leaders alike.

A primary goal must be to enable educationally disadvantaged students to prepare both academically and personally for college and careers in engineering, science, technology, computers and mathematics. Preparation can include hands-on, engaging lessons during the school day, high-level courses (including Advanced Placement and test preparation, after school programming, and enrichment as well as career advising, role modeling and mentoring from peers and adults.

While recent data indicates women are pursuing higher education at record numbers, over three decades since the passage of Title IX, the equal achievement of women in the STEM fields remains an elusive dream. With women comprising 49.9% of the American workforce, as reported by the National Science Board in October 2009, they hold only 27% of available STEM jobs and only 11.5% of engineering jobs.[ii] The time to turn dreams into reality is now. This is a wakeup call to parents, teachers and policymakers. It is the hope of the Diversity Subcommittee that this report will bring sorely needed awareness to the disparities in schools and communities, considering these issues through a "STEM" lens.

Even in the current era of scarce resources, corporate and government financial support must be available to build this pipeline and ensure *all* children are given the access they deserve. By improving access to postsecondary education, enrichment activities, mentorships, internship and externships and higher education experiences, the proportion of underrepresented students who

remain engaged in STEM throughout the pipeline will improve, ensuring better futures for these students and a diverse, robust workforce for the Commonwealth's industries of today – and tomorrow.

This report offers a roadmap to help begin to close the racial and gender gaps in STEM. If the achievement gap is to be closed in an effort to help *all* students achieve success, a solid understanding of our students' strengths and weaknesses is needed. In his book, *The Global Achievement Gap*, Tony Wagner asserts that there is a different form of an achievement gap – one that exists between "overachievers" and those who are "unengaged."

> *"…it can also be defined as the gap between students who are, in a sense, driven to success – the Overachievers - versus those who have little hope of success – those whom I call the Unengaged and how important having adults in their lives who help them discover what interests them and how to harness this. They need opportunities in high school to explore what excites them. There are only three reasons why people work or learn. There is push, which is a need, threat or risk which creates a motivating force; the transfer of habits shaped by social norms and tradition; and pull – interest, desire and passion. This last is the one that increasing numbers of young people are responding to in school and at the workplace."* (p. 200)[iii]

Research shows that policies developed to foster the equitable treatment of students as well as the creation of equitable gender and race educational environments can make a difference. Significant improvements in the educational opportunities available to all children, regardless of their gender, racial or ethnic background, have occurred in the past decades. However, the Subcommittee's findings suggest that barriers to success exist at all academic levels. There are poor support systems, little access to successful role models, lack of access to technology and high-quality engaging courses in STEM, and low expectations and other negative stereotypes contributing to the existing gap.

In a recent report by Wheelock College's *Aspire Institute,* findings indicate that students need to begin training in the sciences and mathematics as early as pre-kindergarten to be successful in today's global economy. By capturing the creativity and imagination of children early on, we can steer them to courses that will nurture students' innate interest and sustain it throughout the entire K-12 grades. Through internships, experiential learning opportunities, integrated technology in educational environments, and technology and engineering education, opportunities are increased both within and beyond the classroom for STEM learning. Having a larger and better prepared STEM faculty at all levels of public education, starting in our elementary and middle schools, will provide role models and high-quality, engaging opportunities for these students. The creativity and imagination that stimulates interest in STEM can be nurtured and developed early on and incorporated into curriculum and lessons. With the involvement of business groups, policymakers, and STEM professionals – all committing to STEM

education and diversifying the pipeline -- partnerships can be brokered and regional and statewide networks of support can be formed.

Collaboration is a powerful strategy through which our Commonwealth can enhance existing opportunities, developing systems that engage students at various points along the STEM pipeline. By working together, the Commonwealth can effectively ensure underrepresented populations are as prominently involved in the STEM fields as their counterparts.

The report is structured to highlight **four strategic initiatives**, principles that the Subcommittee believes are critical to consider when thinking of STEM through a "diversity lens." Each section begins with the rationale and data to support the inclusion of this strategic initiative; describes programs and initiatives from Massachusetts and around the country that demonstrate promising practices for the state to consider when scaling programs and introducing new ones; and provides recommendations for sustainable programming and future collaboration.

Massachusetts is poised to lead the nation in closing the achievement gap and increasing post-secondary success for all students in STEM, regardless of their socioeconomic status, disability, gender or race. This challenge will require dedication of resources, elevating this goal to become a statewide priority, and considering how collaboration among educators, corporations, and community organizations can impact opportunities at each and every phase of the pipeline.

Recommendations for Consideration

The Diversity Subcommittee offers the following recommendations for consideration by the Governor's STEM Advisory Council. These recommendations stem from the belief that encouraging the engagement of underrepresented minorities throughout every phase of the STEM Pipeline requires an "all-hands-on-deck" approach. The four strategic priorities highlighted in this report are four critical areas to be further developed by the STEM Advisory Council.

PARTNERSHIPS

- Foster new public-private partnerships between K-12, institutions of higher education, non-profit organizations and industries.

- Expand upon existing successful partnerships that promote coordination and collaboration among STEM programs that serve girls and underrepresented minority youth, higher education institutions and industry, to create programs whose design is based on evidence of success.

- Engage partners to advocate for public policies and federal resources that support the education and career preparation of students from underrepresented groups.

- Utilize the Regional STEM Pipeline Networks to identify programs that work in their regions and bring those efforts to scale in some meaningful way, with particular focus on enhancing and supporting opportunities for girls and underrepresented youth.

- Base funding and support on the principle of equity, and make investments to create materials and programs that are multilingual, culturally sensitive and accessible to people with disabilities.

EXPOSURE & AWARENESS

- Increase relevant internship opportunities for students in an array of STEM fields and encourage greater participation in teacher externship programs.

- Encourage and incentivize partnerships among industry and institutions of higher education with public schools to promote STEM careers and STEM majors to *all* students regardless of background.

- Engage employees in the STEM fields to serve as role models and mentors to underrepresented minorities and women.

- Increase outreach and provide culturally relevant materials to guidance counselors, teachers and parents that highlight STEM careers and college majors.

AFTER-SCHOOL PROGRAMS & ENRICHMENT

- Build the network of after-school programs and enrichment opportunities available to underrepresented minority youth that have a demonstrated track record of success with these student populations.

- Eliminate barriers to scaling of those ventures by providing funding through public-private partnerships. Programs should be offered free of charge or participation fees should be determined through an ability to pay sliding scale.

- Recognize interventions and program models that work by honoring these programs at the state level.

MENTORSHIP & ROLE MODELING

- Create a statewide strategy that incorporates best practice principles for mentorship, such as cultural relevance, consistency of message and intensity of engagement. The outreach should be done in partnership with community organizations committed to the success of our youth, such as the existing programs outlined in this report. Mentorship programs that do not have a cultural relevancy component will have limited impact, particularly within underrepresented minority communities.

The Diversity Subcommittee's Process

The Subcommittee met three times as a full committee, from March 2010 to June 2010, and identified major areas of focus that would help shape the recommendations for the report. The subcommittee broke into three working groups to conduct further research and analyze material for inclusion in the report.

The three working groups focused on the following areas:

- Collaboration. This working group focused on expanded collaboration in Massachusetts. Effective, sustainable collaboration is critical in order to meet the goal of educating every child to high standards in the STEM fields. Ideas include: industry internships and teacher externships, partnerships with higher education institutions, K-12 schools, industry, and non-profit organizations. The study also considers the role of mentor and role models and the importance of cultural relevance to changing the paradigm for underrepresented populations of students.

- Promising Practices in Massachusetts. This working group focused on programs, initiatives and models in Massachusetts that are designed to engage underrepresented children and youth in the STEM pipeline. Analysis included taking a closer look at programs in Massachusetts that have a proven track record in attracting underserved populations into the STEM fields and retaining them in the STEM pipeline. Programs and initiatives were evaluated to show success, and demonstrate sustainability and scalability.

- National and International Models, Programs and Best Practices. This working group focused on identifying evidence-based models from around the country and throughout the global community that have had an impact on STEM education and have led to an increase in the proportion of females and underrepresented populations pursuing college majors and advanced degrees in STEM-related fields, as well as entering the STEM workforce.

Each working group held two or three conference calls or in-person meetings to assign work and then review their individual work. The process was very effective and allowed each member to provide input and contribute ideas into the final report.

Identifying Strategic Priorities

In order to inform the STEM Advisory Council's five-year plan, the Diversity Subcommittee identified **four strategic priorities** to guide the Council's work in effectively engaging underserved populations and closing persistent achievement and attainment gaps in the STEM fields. This involves introducing STEM to children at a young age, maximizing their innate curiosity, and engaging them in coursework taught by high-quality teachers and enrichment opportunities that introduce them to mentors and role models.

For each of the four **strategic priorities,** Subcommittee members described why this particular priority was chosen (including data to support their assertion). In addition, promising programs, initiatives and practices at the local, national and international levels were identified. When selecting initiatives to highlight in this report, special attention was paid to whether the initiatives have been evaluated to show demonstrated success, scalability, and feasibility to be introduced in Massachusetts. Finally, each section contains recommendations for future collaboration and inclusion of these **strategic priorities** in the five-year plan.

The four **strategic priorities** identified by the Diversity Subcommittee, and highlighted in the following sections of the report are:

- **PARTNERSHIPS**
- **EXPOSURE & AWARENESS**
- **AFTER SCHOOL PROGRAMS & ENRICHMENT**
- **MENTORSHIP & ROLE MODELING**

Data & Framing the Issue

Framing the Issue

The Commonwealth has made significant strides in the last few years to improve the math and science achievement of all Massachusetts students. Indeed, many MA students excel in these subjects in comparison to the rest of the nation, ranking first in math scores in 4th and 8th grade on the National Assessment of Educational Progress (NAEP, 2006-09), and in high school (SAT and ACT, 2009). Performance on international instruments such as Trends in International Mathematics and Science Study (TIMSS) also suggest that that Massachusetts students rank amongst the highest in the world in terms of math and science performance.

However, the high achievements reflect only the top performers in the state: less than half of our 4th, 7th, and 8th graders scored 'proficient' in Mathematics on the 2009 MCAS; just 40% of our 8th graders and less than half of our 5th graders met the 2009 MCAS proficiency standard in Science, Technology, and Engineering.

Math course matriculation and achievement in middle and high school are predictors of future success and interest in STEM.[iv,v] An increase in SAT math score or high school class ranking percentile increased the odds of earning a degree in STEM as compared to earning a non-STEM degree.

By these counts, one would expect Massachusetts students to select STEM majors and graduate with these degrees in high numbers. Instead, test-takers from schools that perform better on the MCAS math test are less interested in pursuing STEM majors than test-takers from schools whose performance on MCAS is worse. According to the *2008 Report of the College Board*'s review of SAT exams, only 22.5% of Massachusetts test takers expressed an interest in pursuing a college major in STEM education, well below the national average of 28% and our leading competitor states.

Addressing the Achievement Gap in STEM

While it is true that overall tests scores on MCAS have improved over time, large proficiency gaps manifest as early as 4th grade for African-American and Hispanic students, those from low-income groups, English Language Learners (ELL), and special education (SPED) students.

For example, just 18% of African-American 5th graders, 13% of African-American 8th graders, and 33% of African-American 10th graders scored 'proficient' in Mathematics on the 2009 MCAS. Rates were comparable among Hispanic students. Just 21% of Hispanic 5th graders, 13% of Hispanic 8th graders, and 28% of Hispanic 10th graders scored 'proficient' in Science, Technology, and Engineering.[vi]

These gaps persist and often widen as students enter into secondary school, as measured by NAEP and MCAS, and impact these students' preparation for and graduation from college in STEM fields.

The reality is that Massachusetts performance is also well below the national average when it comes to the number of African-American and Hispanic students per 1,000 high school juniors and seniors who pass AP math and science exams. Whereas the average score for White students on the 2009 AP Biology exam was 3.22, it was just 2.35 and 1.52 for Hispanic and Black students, respectively. Similarly, whereas the average score for White students on the 2009 AP Calculus AB test was 3.22 it was just 2.74 and 1.94 for Hispanic and Black student, respectively.[vii]

White students who take the SAT are twice as likely to have taken calculus in high school as African-American and Hispanic students. Students from high-income families report having taken calculus at about twice the rate than their counterpart from the lowest income bracket (35% vs. 17%, and 29% vs. 17%).[viii]

One key factor that accounts for these gaps is the quality or preparation of teachers. Nationally, African-American and Hispanic students tend to be taught by less qualified teachers. In 2004, African-American and Hispanic fifth grade students were less likely than white students to be taught mathematics by teachers with a master's or advanced degree (39% and 42% vs. 51% respectively), a regular or advanced teaching certificate (86% and 85% vs. 92%), and more than three years or experience teaching grade five(48% and 58% vs. 68%).

Students from families with low-income status face a similar situation. Eighth grade students from families with low-income status were less likely than those from higher income families to be taught science by teachers with a regular or advanced teaching certificate (79% vs. 86%), a degree or certificate in science (84% vs. 89%), and more than 3 years of experience in teaching science (69% vs. 79%).

The insufficient preparation for college is not only reflected in SAT and AP scores, but also in the disproportionate percentage of African-American, Hispanic, low-income, ELL, and SPED students who receive their STEM-related degrees and certificates from 2-year colleges.

Capitalizing on Student Interest in STEM

An encouraging note from the MA STEM Interest Research Project is the finding that of those students taking the SAT, a similar percentage of African-American and Hispanic students indicate an interest in STEM majors, as compared to white students (24% vs. 26%). African-American and Hispanic students also graduate with similar rates with these degrees (20% vs. 22%), in spite of their preparation and other mitigating factors. However, this may also reflect a high attrition rate, since a 2005 study found that nearly half of all Hispanic students throughout the US who declare majors in engineering or science change majors during college and do not earn a degree in either area.

Also, there is an inverse relationship between interest in STEM and the following: students' family income; those attending schools with a higher percentage of low-income students; and actual performance on the SAT. In particular, students from vocational schools, i.e. those with practical experience in STEM, are much more interested in STEM majors than their counterparts (32% vs. 24%).

Thus, an exciting opportunity exists for the Commonwealth to invest in improving both the quality of education, in particular math education for students from these underrepresented groups, and hands-on/practical experiences to all students in order to achieve the Subcommittee's goal of increasing the number of graduates with STEM degrees.

Is There a Gender Gap?

As pointed out earlier, math course matriculation and achievement are correlated with STEM major selection. Given that women score higher on the Math section of the SAT than men, and more females score towards the top of the scale on the Math section of the SAT than males (51% vs. 38% test takers scored at or above 500 in Math on the 2009 SAT test),[ix] one would expect a higher proportion of women to graduate with STEM majors. That female graduates in science, engineering and health fields outnumber males 56% to 44% may lead one to this conclusion. However, this can be partly accounted for by the higher number of women who graduate from high school and who enter college.

On the other hand, the findings on the proportion of STEM degree holders in relation to all bachelor's degrees obtained, the attrition of female students who were interested in STEM become evident: the proportion is 20.4% for women vs. 25.8% for men, while a similar percentage of women expressed interest in STEM as men (24.1% vs. 26.3%) as surveyed during SAT test taking.

Additionally, wide gender disparities persist in certain majors. While 86% of health and 77% of psychology bachelor's degrees were awarded to females, 78% of engineering degrees and 77% of engineering and computer/information science bachelor's degrees were awarded to male students.[x]

Conclusion

The prominent academic achievement in math and science of Massachusetts students nationally and internationally is marred by the lag in achievement for African-American, Hispanic, ELL, SPED and low-income students. The good news is that these students are similarly interested in STEM, if not more so, than their better-performing counterparts. This suggests that efforts to increase interest overall will have a similar impact on these groups, and efforts to increase these groups' capacity to pursue higher education in these fields can be an important contributor to increasing the overall number of STEM graduates.

Similarly, particular efforts must be made to retain female students who are interested in STEM, and to attract them to fields such as engineering and computer science, which continue to suffer from a disproportionate representation of females in college matriculation and in the workforce.

To achieve the goals of the Subcommittee, and to raise performance overall, special attention must be provided to these groups as follows:

- The current goal of the STEM Advisory Council to increase proficiency is absolutely critical. However, an overall 5% increase for all groups would only lead to the persistence of the achievement gap. In addition to the specific recommendations highlighted in this the report, the benchmarks need to be more explicit to reduce proficiency gaps between various groups.

- Similarly, the goal to increase the number/percentage of individual STEM classes led by qualified teachers must also specifically address the disparity between schools with a large population of students from low-income families and other schools that may educate very few students from a similar background.

- While the movement to increase the number of students taking AP courses to prepare them for college is laudable, benchmarks must be established to ensure that achievement across all groups, rather than mere participation in these courses and exams, are measures of programmatic success.

- Given that female students clearly have the capacity to excel in the male-dominated STEM fields, strategies that demonstrate increased participation in these fields (see AAUW report[xi] for examples) must be integrated into teacher training and other recruitment and retention strategies. What this report in particular points to is that a combination of academic, psychological and socio-cultural approaches is essential to increase broad participation in STEM.

Strategic Priority 1: PARTNERSHIPS

RATIONALE

According to the 2008 Bureau of Labor Statistics, Occupational Employment Statistics Survey (OES), engineers comprise 1.59% of the Commonwealth's workforce; life and physical scientists make up 0.79% and computer specialists account for 3.27%. STEM related jobs pay higher wages and have greater levels of job security during down economic periods than other sectors. Over 85% of recent college graduates in the areas of science, engineering and health were working in April 2006.[xii] The number of biotech companies in Massachusetts has grown from 280 in 2002 to 400 in 2010 - there were 30,000 biotech jobs in Massachusetts in 2002, there are 40,000 in 2010. There is an incredible gap between the jobs that exist and the number of underrepresented minorities from the Commonwealth who are filling those jobs.

Considering the aforementioned statistics, it is vital that new partnerships be formed and current partnerships be expanded to ensure that opportunities are maximized for every student in Massachusetts, particularly students from underrepresented groups. Establishing formal partnerships with the private sector is absolutely essential to ensure that girls and underrepresented minorities are able to get the necessary training to qualify them for a wide array of employment options in these fields. Partnerships with biotech, science and engineering companies who provide internships, job shadowing and summer employment are ways to provide role models and enrichment as well as exposure to careers and opportunities. Professional organizations for both Latino/Hispanic and Black engineers and scientists as well as those networking groups who focus on women in STEM should be enlisted to do outreach and mentoring to these youth and to provide experiential learning to encourage their early interest. These organizations can also provide speakers at events who can address how they broke down barriers to become successful in their careers.

The *Gathering Storm* report[xiii] for improving STEM educational performance and the US STEM workforce put forth the following recommendations which are useful for the Commonwealth to consider as it embarks on planning for a five-Year STEM agenda.

- Enlarge America's talent pool by greatly improving K-12 STEM education through the recruitment, training and retention of STEM teachers
- Expand the STEM Pipeline, especially targeting women and minorities, by increasing the number of students who pursue STEM coursework; and
- Make the US the most appealing setting for study and research to cultivate, recruit and retain top quality students, scientists, and engineers from within the US and throughout the world.

BEST PRACTICES

Partnerships between K-12 and the STEM industry in Massachusetts

Web Tools and Professional Development. The Verizon Foundation partners with the Massachusetts Department of Elementary and Secondary Education (ESE) in collaboration with Lesley University to provide professional development opportunities to train teachers to use Verizon Thinkfinity.org -- a free, comprehensive website containing more than 55,000 standards-based educational resources across all subject areas. By the end of 2010, more than 4,000 Massachusetts teachers will be trained to use Thinkfinity.org in the classroom. The Verizon Foundation also has given $10,000 grants to schools and school districts across the state to use Thinkfinity.org to help improve student achievement in STEM subject areas. Since November 2007, the Verizon Foundation has contributed more than $500,000 to support the use of Thinkfinity.org in Massachusetts public schools.

High School Internships. Many corporations and organizations throughout the Commonwealth hire high school interns during the summer to work on interesting STEM projects.

STEM Scholarships. Draper Laboratory has supported STEM scholarships for graduating high school seniors through partnerships with Engineers Week - New England, The Society of Mexican American Engineers and Scientists (MAES), and the Society of Hispanic Professional Engineers.

STEM Educator Externships. The Leadership Initiatives for Teaching and Technology (LIFT2) program is an innovative professional learning program for middle and high school STEM teachers. It is designed to help experienced and developing teachers relate classroom curriculum to authentic and relevant applications in the 21st century workplace. The program is based on a unique combination of graduate coursework, company sponsored externships in industry, the cornerstone of the program, and membership in an active community of learners. Industry externships offer teachers five to eight weeks of paid summer employment in challenging and exciting work placements appropriate to their curriculum focus and professional interests. Through externships, teachers:

- See math and science principles applied in everyday industry settings.
- Are exposed to the pervasive use of information technologies in data collection, analysis, problem solving and communication—critical skills for the 21st century.
- Experience the culture of today's workplace that emphasizes collaborative teamwork, critical thinking, global perspectives, and multi-media communication

Diversity and Inclusion. Equitable diversity and inclusion goals in industry have an impact on the documented achievement gap in Massachusetts STEM education. Raytheon Company embraces these goals and is sensitive to the downstream value to STEM education through the educational outreach of employee volunteers.

School Participation (employee volunteering from schools). Many in the field encourage employees regularly volunteer to visit middle schools and high schools through partnerships with STEM-focused diversity organizations such as the Society of Women Engineers, the National Society of Black Engineers, and the Society of Hispanic Professional Engineers.

Community Involvement (employee volunteering for local STEM organizations). Laboratory staff volunteer with local STEM organizations like Science Club for Girls, US For Inspiration and Recognition of Science and Technology Robotics, Tutoring Plus, and Engineers Week - New England.

Partnerships between K-12 and Higher Education

Institutions of higher education provide programs for students from underrepresented groups; programs for women in STEM; professional development for teachers; resources for teachers, K-12 students and parents; STEM career awareness programs; collaborative programs development assistance; STEM workshops; STEM curriculum development; and "Bridge" programs.

University of Massachusetts Amherst - Women in Engineering & Minority in Engineering Programs. The Women in Engineering Program (WEP) was started in 1983 with a gift from GTE Corporation. The mission of WEP is to reach and inspire college women to pursue their potential in engineering and technical careers, while supporting them throughout the process. WEP is a support program that provides academic and non-academic assistance to women to help them realize their potential as students and as engineering and technical professionals. To this end, WEP hosts activities and provides resources that offer student learning, networking, and service opportunities on professional development issues both before and after graduation. Upon acceptance to the UMass Amherst College of Engineering, all women students are automatically enrolled in the program and are allowed to participate in all WEP activities and have

About the Urban Massachusetts Louis Stokes Alliance for Minority Participation (UMLSAMP):

This program is an alliance with eight member institutions to increase the quality and quantity of underrepresented minority students completing baccalaureate degrees in STEM fields. Alliance members include UMass Boston, UMass Dartmouth, UMass Lowell, Bristol Community College, Bunker Hill Community College, Middlesex Community College, Roxbury Community College, and Wentworth Institute of Technology. This program is funded by the National Science Foundation with support from its institutional members, state agencies, and corporate enterprises. UMLSAMP is dedicated to the retention, persistence, and graduation of all undergraduates, especially underrepresented minority students in STEM fields. A summer bridge program that prepares college entering students in math and sciences is an integral component of the UMLSAMP success.

access to all WEP resources.

Northeastern University - Women in Engineering Program. Northeastern's Women in Engineering (WIE) Program connects students with mentors, tutors, career advice, financial aid, and other women in engineering - all the resources that promote success in engineering. Starting with one of the housing choices for freshmen, students can make connections with other women studying engineering through the Connections Learning Living Community. The WIE program offers both one-on-one tutoring as well as review sessions in key engineering and science classes. As an upper-class student, there are opportunities for students to develop leadership skills by mentoring and inspiring younger girls from middle and high school. Guest speakers and a career management course give students access to working women engineers who encourage the pursuit of an engineering education and career.

National Partnerships

Partnerships with national membership associations including SWE, (Society of Women Engineers); NSBE (National Society of Black Engineers) SHPE (Society for Hispanic Professional Engineers) ASME (American Society of Mechanical Engineers), ASEE (American Society for Engineering Education), IEEE (The Institute of Electrical and Electronics Engineers, AIChE (The American Institute of Chemical Engineers offer the following activities: hands-on learning activity that addresses STEM curricula; outreach to university department heads from education, engineering, and mathematics to develop a pre-college engineering education plan for their institutions; mentoring programs; STEM workshops; informational interviewing; job shadowing; merit certificates; scholarships; STEM professionals volunteering in K-12 schools and universities; teacher resources; student resources; parent resources and grants.

Northrup Grumman Electronic Systems STEM Initiatives: For more than two decades, Northrup Grumman Electronic Systems employees have taken part in programs to engage students (K-12) in discussion of STEM disciplines as possible careers. At its simplest, this form of community outreach allows engineers to convey their enthusiasm about engineering, provides the students with some exciting and relevant activities and helps promote science and math in our schools.

- *TEAACH Internship Program.* To help develop tomorrow's technical talent, Northrop Grumman Electronic Systems introduced the Teachers and Engineers for Academic Achievement (TEAACH) internship program. The program, which is similar in structure to the LIFT2 program in Massachusetts, is operated in Illinois and Maryland. As a result of mentoring programs like TEAACH, Northrop Grumman has received an increasing number of requests from schools to have engineers visit and provide an overview of career options in engineering and technology. One response to this request is the creation of the REAACH program that will team experienced engineers with teachers to influence an even larger number of students.

Spotlight on Wentworth Institute of Technology's Partnership with O'Bryant High School of Math and Science

Wentworth is expanding an established mentoring relationship with the John D. O'Bryant High School as part of a more effective and integrated service learning initiative to include tutoring, student orientation, and course development. The O'Bryant High School is part of the Boston Public Schools. The following programs highlight this partnership:

- **FIRST Robotics**: This past academic year, Wentworth students work closely with O'Bryant students to design, engineer, and build a robot for the FIRST Robotics competition. Apart from the robot's functions and material specifications, the O'Bryant students were free to create the robot in any way they wished. Wentworth student mentors helped advise, instruct, and support the high school students from the start of this process all the way to coaching the robot operators on the floor at the regional competition. On Saturdays and after school, Wentworth students attended build sessions during which they assisted O'Bryant students in designing, programming, constructing, and testing the robot.
- **Dual Enrollment**: O'Bryant High School students are provided the opportunity to begin college academics at Wentworth while completing their high school education in a collaborative dual enrollment, tuition-free program. During the fall semester, students enroll in an undergraduate course, *Introduction to Technical Communications*, and successful completion results in course credit at the high school and college level.
- **N.E.X.T. Program**: The Networking Excellence Experiencing Teaching (N.E.X.T.) program provides Wentworth student mentors to O'Bryant students. Through a series of workshops, Wentworth students offer advice on a range of post-secondary topics including the college admissions process, writing essays, and what to expect in college.

- *School Visits and Classroom Activities.* Every year, beginning after National Engineers Week, Northrop Grumman engineers take a day to visit a school of their choice and lead a hands-on classroom activity related to engineering and generate excitement about technical professions. Northrop Grumman give-a-ways are provided to students and lesson plans shared with the teachers. Each school visited is given a grant to be used to enhance their math and/or science programs.

General Electric and MC²STEM High School Partnership. Many GE employees provide hundreds of hours every month in direct student engagement at MC²STEM High School through four different programs:

- *Job-shadowing* allows students to see GE employees from various departments (project management, pricing, sourcing, human resources, legal and technology) in a work setting drawing a link between what they learn in school and how it relates to different career choices.

- The *sophomore project* guides student teams through development of a new product from concept and brainstorming through to fabrication and marketing. The capstone of the class is an end-of-year "trade show" at which students "sell" their product.

- *Lunch buddies* allow informal mentoring between professionals and students.

- *Lunch with the CEO* awards eight teacher-nominated students the opportunity for a private lunch hosted by the CEO. Students are selected based on exhibiting outstanding personal achievement as well as exemplary behavior.

<u>RECOMMENDATIONS</u> (partly adopted from NACME):

- Form partnerships between corporations and K–12 schools to promote STEM careers and education to underrepresented minority students. Provide STEM employees to serve as role models and mentors, offer on-site internships to students and teachers, and providing access to the latest equipment and software.

- Encourage/advocate for public policies that support the education and career preparation of students from underrepresented groups.

- Recruit underrepresented minorities as part of workforce development and hiring strategies, and broaden college recruiting efforts to include institutions that traditionally enroll large numbers of underrepresented minorities.

- Educate on partnerships development principals and provide a tutorial on "how to develop partnerships. This will in turn help encourage the sharing of best practices. For example, the DOME Foundation is a local non-profit group whose mission is to broaden awareness of and to increase participation in the STEM disciplines by underrepresented populations to meet the needs of a globally competitive workforce. The DOME Foundation organizes symposia in Massachusetts to disseminate knowledge about research, policy and best partnerships practices that increase the participation of women & students from all underrepresented groups in.

- Encourage externships for teachers (see LIFT2 program above).

- Many factors affect the number of students who ultimately pursue STEM careers. The model attempts to capture these factors through a series of dynamic hypotheses and more than 200 unique variables. Using complex algorithms, the tool simulates and assesses the impact of STEM-policy and programmatic interventions during a period of time to determine which produce favorable outcomes. With the generous support of the Bill and Melinda Gates Foundation, Raytheon, BHEF and Ohio State University are now working with a network of researchers and modelers to refine the U.S. STEM Education Model and make it available as an open source tool.[xiv]

Strategic Priority 2: EXPOSURE & AWARENESS

RATIONALE

STEM careers have a double importance to our society. First, these careers are well paid and candidates are in high demand. As a result, graduates of STEM programs have an increased chance of finding good jobs that provide a wage that will support themselves and their families. In fact, tech jobs in Massachusetts pay an average of $87,784 per year compared to the state average salary of $49,070 according to *The IT Industry: Hub of the Massachusetts Technology Economy*.[xv] The report indicates that while there are opportunities for workers with different levels of education, nearly two thirds of employees working in the state's tech sector have a bachelor's degree or higher.

Second, the tech sector and technical jobs in more traditional sectors are crucial for future vitality in the global economy: any country that wants to compete needs a well-trained, highly educated and technically capable workforce.

However, there are several underrepresented groups pursuing STEM studies and careers, including women, minorities and people with disabilities. These groups need considerable support to increase their awareness of and exposure to possible career choices, in an effort to provide all students equal access to an education that prepares them for opportunities in the STEM fields.

Even within populations of students that do well in STEM studies, many are not choosing to pursue STEM majors in college or STEM careers upon graduation. A recent Massachusetts Business Roundtable report *Tapping Massachusetts' Potential*, expressed urgency on behalf of the business community to make STEM a statewide priority. The report identified that, according to the College Board, in 2009, only 22% of Massachusetts SAT takers identified STEM disciplines as their probable career of choice. The national average is 26% and states like North Carolina are in the 30% range.[xvi] There is even a gap in interest from students who excel in STEM subjects choosing college majors and careers in STEM. This poses a true growth problem for STEM education.

It is critical to the Massachusetts' economy that the STEM pipeline is strengthened and better prepares more students, including women and minorities, to think of STEM careers as an option. For example, more women are joining the workforce with over 49% part of it in 2010. In the elementary, middle, and high school grades, both girls and boys take math and science courses in roughly equal numbers. However, while equal numbers of boys and girls leave high school prepared to pursue science and engineering majors in college, fewer women than men choose these majors. By college graduation, men outnumber women in nearly every science and engineering field, and in some fields, such as physics, engineering, and computer science, the difference is dramatic, with women earning only 20% of bachelor's degrees.[xvii]

In general, there is a challenge in attracting women to STEM studies and ultimately careers. To diversify STEM fields, we must increase the pool of girls that have an academically strong interest in math and science, and diminish the negative stereotypes and biases our culture holds regarding women in STEM careers. Encouraging more girls and women into these fields will require more attention to the environment in the classroom and in the workplace.

While minority populations are becoming a larger component of our state's population, barriers exist for attracting them in large numbers to STEM education and careers due to lack of access, socioeconomic issues and stereotypes. The Hispanic population in the US has been growing at dramatic rates over the past few decades and from 2000 – 2006 Hispanics accounted for one-half of the nation's growth. The Hispanic growth rate (24.3%) was about four times the growth rate of the total population (6.1%). An analysis of the school districts throughout Massachusetts with the highest percentage of Hispanics shows that 57.2% of the total Hispanic student population resides within the ten cities with the highest percentage of families living below the poverty level. These cities educate 18.2% of the total population of school-aged children in Massachusetts. Socio-economic and cultural barriers limit the availability of the critical resources necessary to educate this student population. The public schools need assistance to create outreach and marketing to educate the students, parents, and community members that STEM studies and careers offer ways to improve their students' lives for the greater good.

Technology Engineering Education:

This underutilized area of study is part of a comprehensive public school which offers hands-on explorations into technology, innovation, design, and engineering that helps young people develop an understanding and competence in designing, producing, and using technological products and systems while assessing the appropriateness of technological actions. STEM career awareness is one of the organic experiences in these kinesthetic learning activities. In 1993 (and reaffirmed in 2003) the Massachusetts curriculum frameworks for Science, Technology/Engineering included Technology Education as a core subject from Pre-K-12.

BEST PRACTICES/PROMISING PRACTICES

There are pockets of programs throughout Massachusetts that are effectively raising awareness and student achievement in STEM. Included in this section are three options that raise awareness and exposure for teachers and students from kindergarten through post-secondary education.

The ***Engineering is Elementary*® (EiE)** program,[xviii] created by the Museum of Science in Boston in 2003, has both statewide and national reach. The program fosters engineering and technological literacy among children with a focus on grades K–5. EiE offers elementary school teachers a research-based, standards-driven, and classroom-tested curriculum that integrates engineering and technology concepts and skills with elementary science topics. Storybooks

featuring children from a variety of cultures and backgrounds introduce students to engineering problems. Also as part of EiE, students are then challenged to solve a problem similar to the problem faced by the storybook character. Through a hands-on engineering design challenge, students work in teams to apply their knowledge of science and mathematics; use their inquiry and problem-solving skills; and tap their creativity as they design, create, and improve possible solutions. The goal is to show students that anybody can be an engineer. More than 1.1 million students and nearly 19,000 teachers across the United States have participated in the EiE program to date.

Technology Engineering Education reaches middle and high school students and offers a scalable way to offer hands-on, holistic learning experiences that relate to LIVE STEM standards -- using math, science, and English language arts in content and context -- for middle and high school students. The state's 380 middle schools are the key places to create an understanding of the broad opportunities our students face. The goal, according to the National Academy of Engineering, is to create "technologically literate citizens who: [xix]

- Recognize the pervasiveness of technology in everyday life.
- Understand basic engineering concepts and terms, such as systems, constraints, and trade-off.
- Are familiar with the nature and limitations of the engineering design process.
- Know the ways technology shapes human history and people shape technology.
- Know that all technologies entail risk, some that can be anticipated and some that cannot.
- Appreciate that the development and use of technology involve trade-offs and a balance of costs and benefits.
- Understand that technology reflects the values and culture of society.

Research indicates that young students (4th through 8th grades) are most receptive to learning experiences that challenged them to think outside of their cultural and socio-economic norms.[xx] These ages were also described as the gateway to adult attitudes and perceptions that open or close doors of study and career choice.

Furthermore, high school graduation requirements in Massachusetts have been expanded to include the successful completion of one high school technology engineering course as a recognized fourth science course. It also has the potential to help kinesthetic learners (Gardner, 1993) fulfill their graduation requirements by taking the Technology/Engineering MCAS test instead of the Biology or Physics tests. Instead, the modern technology engineering courses offer hands-on problem solving and STEM learning experiences that accentuate the Technology and Engineering connections to real world careers. These courses, especially ones that offer an awareness of the communications industries, have been shown to attract young women to STEM studies.[xxi]

Boston Area Advanced Technology Education Connections (BATEC) is a partnership comprised of six community colleges in and around the city of Boston, the Boston Public Schools, thirty additional school districts surrounding the city of Boston and the University of

Massachusetts Boston. Through a National Science Foundation-funded Regional Center for Information Technology (IT), *BATEC* is transforming education by developing the IT professional for the 21st century through curriculum that is regionally connected, and advanced in content and pedagogy that is linked to industry; providing professional development experiences for educators so they can deliver relevant, standards-based programs of instruction that model the reality of the workplace; attracting and advancing a diverse population of technology students who can effectively meet the challenges of emerging technologies and changing economies; and connecting education, industry and community to promote mutually-beneficial partnerships that support career development, lifelong learning and regional economic growth.

More than 500 educators have engaged over 5,000 students in performance-based learning exercises that make use of case and/or problem-based methods, and are connecting industry, educators and students in an open dialogue about the future of STEM education.

RECOMMENDATIONS

To encourage students from all backgrounds to develop an interest in science, this subject area should receive equal instruction time in the elementary grades. In an education system that compartmentalizes subjects and students, science has taken a back seat to English Language Arts and mathematics in some schools. American society tends to label students early on based on their personality traits and interests. If they do not receive a strong grade in science early on, we tend to steer them away from pursuing advanced courses in the subject area. Labels at home, in the community and at school can hurt students performance in the STEM subject areas. Increased science instruction, integrated with math content, will allow all students a higher level of comfort and desire to follow paths in the STEM fields.

While many after school programs focus on strengthening math, science and technology skills, they only reach small, targeted populations. In order to encourage systematic change in the attitudes toward STEM, changes need to be made during the core school day. Science should not be viewed as a subject teachers feel needs to be "squeezed" into the regular day. Instead it should have a consistent, hands-on component. It is important to focus not only on content but context. Literacy can be integrated across all content areas and this integration can help excite students about STEM subject areas early in their educations.

Professional development is needed for elementary school teachers who are not comfortable with STEM subjects. Educators need to have a better understanding of the importance of these subjects and an awareness of how they will better prepare students for successful careers. Externship opportunities within private industry can also help teachers in the higher grades better understand how STEM subjects link to careers.

Technology Engineering course instruction should be offered in K-12 schools to help all students learn how to use and apply technology through critical and creative thinking and problem-solving. These programs provide all students with activities concentrated in an action-based, problem-solving, solution-seeking format, in the areas of: communication,

construction, manufacturing, power/energy, transportation and biotechnology. Technology engineering education presents an integrated approach to education through organized programs that emphasize career awareness, consumer knowledge, impacts and consequences of technology, and an understanding of the technical systems through the application of science, mathematics, language arts and educational technology.

Elementary school teachers need professional development workshops to bring the teaching of science and technology/engineering up to world class levels. These are especially critical to those teachers whose students come from underprivileged, lower socio-economic communities.

Mentors can help provide public awareness for STEM within diverse communities. Mentors can be used to reach teachers, parents and, most importantly, students in their communities. It is important that mentors reflect the diversity of the students, helping raise awareness about the potential for those who are strong in STEM. For example, business leaders could mentor college students, college students could mentor high school students, and middle school students could mentor elementary school children. Engaging students in their communities through social organizations, churches, and after-school programs can complement classroom experiences. Mentors can also be used to promote STEM careers.

Strategic Priority 3: AFTER-SCHOOL PROGRAMS & ENRICHMENT

RATIONALE

Research reviewed for this report challenges traditional assumptions about the egalitarian nature of Massachusetts and American schools. Girls and youth from underrepresented groups are not benefitting equally from our education system. Specifically relating to the pursuit of STEM studies and careers, female and underrepresented students do not receive equitable amounts of teacher attention or encouragement, and they are less likely to see themselves reflected in the materials they study. In March 2010, Bayer Corporation released a survey that highlighted the causes of underrepresentation in STEM fields by evaluating the experiences of female, Hispanic, African-American and American Indian scientists from childhood through the workplace. The survey found social and economic factors at the center of the disparity, noting that girls and underrepresented groups showed early interest in the sciences, but their interest was seldom nurtured or encouraged as they progressed through school. More than 77% of those surveyed reported the reasons for the disparity in representation in STEM careers is that girls and under-represented minorities were not identified, encouraged or nurtured to pursue STEM studies as youngsters.[xxii] Programs that foster girls and underrepresented minorities in STEM studies outside of the traditional educational environment can make a difference.

With the new federal "Educate to Innovate" campaign to motivate and inspire students to excel in STEM subjects, Massachusetts now has a window of opportunity that cannot be missed. We must move girls and minority groups to the center of our educational focus. We cannot ignore their potential and we need to look beyond the classroom. This is imperative given that, on average, students, regardless of their gender or race, spend 80% of their time out of a traditional school setting. Therefore, one of our strategic themes is the area of after-school programming and enrichment of experiences for students in these demographics.

Currently, in the out-of-school and expanded learning time communities, there is a renewed interest in implementing after-school programs with a particular focus on STEM-related activities. There is a large field of models to pull from; however, there is not a large amount of outcome based measurements or evaluations, particularly around impact across gender and race. Identification of those after-school and enrichment programs that have been successfully implemented and sustained for at least two consecutive years in Massachusetts as well as throughout the country need to be identified and replicated.

Some of the most important factors to consider in evaluating STEM after-school and enrichment programs are the learning styles and environments that best foster female and minority interest and success. Hands on and experiential learning have been shown to be more successful for girls. And, for both girls and minorities, the presence of a role model who they can relate to - instructors and mentors who show that women and minorities can succeed in STEM careers – creates an environment that encourages and supports their interests. Schools and communities

must showcase role models in scientific and technological fields, disseminating career information and offering hands on experiences and work groups in science and math classes.

The National Research Council (NRC) recently affirmed that structured, non-school environments offered by community-based science programs and science museums can nurture the interest of children in STEM, improve their academic performance, and help them see a future in science.[xxiii] Local schools should seek strong links with businesses, youth serving organizations that have developed successful out of school STEM programs, as well as with local colleges and universities and private and charter schools that are encouraging this direction in their student body. Working collaboratively, these groups can explore partnerships through Regional STEM Pipeline Networks.

While many American teenagers expressed interest in STEM careers, nearly two-thirds indicated that they may be discouraged from pursuing those careers because they do not know anyone who works in these fields (31%) or understand what people in these fields do (28%).[xxiv] Given this finding, the establishment of formal partnerships with the private sector will ensure that girls and minorities get the training which will qualify them in nontraditional areas for employment. Partnerships with biotech, science and engineering companies who provide internships, job shadowing and summer employment for the targeted groups are ways to provide role models and enrichment as well as exposure to careers and opportunities.

Professional organizations for both Latino/Hispanic and Black engineers and scientists as well as those networking groups who focus on women in STEM should be enlisted to provide outreach and mentoring to these youth and provide experiential learning to encourage their early interest.

Finally, the after-school workforce should not be overlooked as an important contributor to the dissemination and implementation of STEM programs, especially for low-income children. As the *Coalition for Science After School's Blueprint for Action* suggests, incorporating current knowledge of science teaching and learning into staff development of youth workers, together with the provision of high-quality curriculum, can greatly expand and increase the quality of STEM experiences available to youth. Such training is currently provided in the state by the Education Development Center and the Boston Children's Museum and should be expanded.

Federal and state funding should be used to promote partnerships between schools, universities, local businesses and community groups, including social service agencies, and youth serving organizations. The Commonwealth has made progress in this regard by reinstating funding to the Regional STEM Pipeline Networks. These Networks are ideally positioned to capture information about STEM activities in their region and share findings with local school districts.

BEST PRACTICES

The U.S. Departments of Education and Justice (2000)[xxv] found that characteristics of high-quality after-school programs of any type include clear program goals, strong leadership and effective managers, skilled and qualified staff, ongoing professional development, and low adult-to-child

ratios. Using these characteristics as a basis of evaluating which programs may have the highest success rate over an extended period of time, the following represent some of the most promising best practices in out-of-school and expanded learning time specifically in STEM education:

- **Hands-on learning**: Students learn best through hands-on learning. This is particularly true with science and technology education, which comes to life when students can conduct their own experiments, do their own programming, and test their own designs.

- **Working with experts**: In order to inspire students to pursue STEM careers, students must have the opportunity to work directly with experts at the forefront of their fields. By building relationships with real scientists, students are able to envision themselves in STEM careers, and discover the excitement of working in the innovation economy.

- **Teaching back through public displays of learning**: Students learn and retain skills the most powerfully when they have had the opportunity to teach what they have learned to others. In addition, presenting their work to an audience inspires students to work hard, and boosts their confidence.

- **Deeply engaging students and families**: In addition to inspiring students to choose STEM careers, it is also important for parents to learn about the promise of STEM careers so that they can encourage their children to pursue these growing fields.

- **Measureable:** Programs that participate in third-party, longitudinal studies to track effectiveness in engaging students, and tracking their involvement and participation in STEM career pathways.

- **Sustainable:** Increasingly, we recognize that the state, private sector and philanthropic communities are receiving numerous requests for funding and therefore encourage all programs to identify future funding sources today and plan for future growth in a sustainable, thoughtful manner.

- **Scalable:** Programs should be positioned for future growth and have ability to scale to regional, if not statewide capacity.

Statewide Programs Exhibiting Best Practices

Metro South/West Regional Employment Board (MSWREB) Saturday STEM Academy. The Technology Initiative of the Metro South/West Regional Employment Board (MSWREB) is focused on "providing a multi-dimensional systems approach to increasing K-12 student academic preparation, awareness, interest, and motivation for pursuing postsecondary majors and careers in STEM fields… recognizing that there can be no hope of increasing the STEM pipeline without increasing the diversity of the STEM pipeline… (and placing) research and evaluation (as) integral" to their programs. The initiative has developed a program, *Saturday STEM Academy,*[xxvi] serving high school female and minority students. The program is annually evaluated through a third party longitudinal assessment to measure impact, specifically the increase in numbers of

high school students choosing postsecondary majors in STEM. In May 2009, eighteen high school freshmen completed the inaugural semester, with sixteen of them returning in their sophomore year.

Girl Scouts of Eastern Massachusetts. Girl Scouts provides activities packaged in an attractive and accessible format which allows girls K-12 to experiment with subjects like science and math in a safe and secure environment in which all girls are encouraged to participate. Girl Scouts has developed exciting STEM programs that are research-based and measured, educational and fun and that focus on activities girls use in everyday life. Many of these programs are collaborations with local universities such as Simmons, MIT, and Middlesex Community College; businesses such as Raytheon and Draper Labs; and other non-profit and government organizations such as NASA, TERC (Technical Education Research Centers), Citizen Schools and the National Science Foundation.[xxvii]

Science Club for Girls. Designed to increase interest, confidence, literacy in STEM, and career awareness in girls from the earliest age, Science Club for Girls connects adult women in STEM to young girls in grades K-7 through eight-ten week long hands-on explorations. The curriculum provides depth by focusing on particular themes during the semester, while introducing the spectrum of natural sciences and engineering across grades. The program encourages learning by teaching and reinforces 21st century skills through a near-peer mentoring model, with middle and high school girls serving as junior mentors. Adolescent girls may also participate in innovation teams, ranging from rocket clubs to sports medicine. These programs are supplemented with field trips and speakers where careers in STEM are explored in greater depth. The organization also actively promotes additional enrichment opportunities, including internships, to parents and girls. To remove barriers to participation, programs are free and junior mentors are provided with a stipend.

Science Club for Girls has doubled its enrollment since 2006, serving approximately 1,000 students in eastern Massachusetts in the 2009-10 academic year through its various programs, with a focus on girls from underrepresented groups. In recent years, almost 100% of high school participants in the program entered 4-year colleges, with more than 55% choosing STEM-related majors.[xxviii]

Massachusetts State Science & Engineering Fair (MSSEF). For six decades, MSSEF programs have advanced science literacy and inspired new generations of science and engineering leaders. Over 26,000 students have participated in Massachusetts statewide fairs, and many thousands more have been part of the state fair pipeline: regional and school-based fairs across the Commonwealth. In addition, MSSEF has been promoting inquiry-based learning in science for over a half-century. The MSSEF programs engage sustained student interest, increasing science literacy while also developing students' 21st century workplace skills, such as communication, teamwork and a strong work ethic. MSSEF's five-year strategic outreach plan, the "Curious Minds Initiative" (CMI), aims to engage every Massachusetts school district in inquiry-based learning, providing science teachers with the tools, expertise and resources needed to implement project-

based learning and school-based fairs. MSSEF programs are thriving in diverse communities. Currently, 40% of students come from schools in high-need districts, and over 50% are young women.

YouthWorks Program. YouthWorks is a state-funded youth jobs program, providing funds to pay wages to low-income youth for summer jobs in the public, non-profit, and private sectors. Commonwealth Corporation administers the program on behalf of the Massachusetts Executive Office of Labor and Workforce Development. Participants are typically employed up to 30 hours per week over a six-week period during the summer. Last year, YouthWorks provided employment to 4,260 low-income youth across Massachusetts. Of all youth served in the 2008 summer program, 89% were in-school, 3% had already graduated high school but were not enrolled in school, 3% were enrolled in a postsecondary program, and 2% were high school dropouts; 42% were Black or African-American and 33% were Latino. A STEM-focused arm of this program could be implemented to engage this group of mostly underrepresented youth in STEM studies and careers.

National Programs Exhibiting Best Practices

Citizen Schools. Citizen Schools partners with middle schools to expand the learning day and change the life trajectories of low-income children across the country. Citizen Schools mobilizes a second shift of afternoon educators, who use hands-on, relevant activities to provide academic support, leadership development, and college and career preparation. Citizen Schools recruits, trains, and supports experts – engineers, astrophysicists, architects, entrepreneurs, biotechnology scientists, computer programmers, and others – who volunteer to teach real-world "apprenticeships" in which students produce something of value and present it back to the community.

VEX Robotics. VEX Education exists to help schools focus on practical, affordable and accessible ways of delivering dynamic hands-on STEM educational experiences to as many students as possible. Mixing the excitement and motivation associated with competition and real-world applications of mathematics and science concepts through the use of the engineering design process, the VEX Robotics program focuses on addressing current educational and societal needs on many levels.

In a Brandeis University survey of VEX Robotics participants, 90% or more report increased understanding of the value of working on a team, how science and technology can solve problems, and the engineering design process. More than 80% or more report increased interest in science and technology careers. Over 90% also report that they learned about working on a team, using trial and error, working with team members to solve a problem, and managing their time.

InnoWorks. InnoWorks aims to provide middle school students from disadvantaged backgrounds with an opportunity to explore real world applications of science and engineering

principles. The program promotes teamwork, enthusiasm for learning, and serves to encourage career interests in science, technology, engineering, math, and medicine (STEM2) through summer camps run entirely by undergraduate and graduate students. InnoWorks has chapters at Duke University, University of Pennsylvania, University of Maryland, University of Arizona, Boston University, Harvard, MIT, and other institutions.

Each one-week to two-week long InnoWorks program consists of three different types of activities: interactive presentations and mixed-team learning activities, team-building activities, and fast-paced competitive missions.

RECOMMENDATIONS

The state should:

- invest resources in scaling programs with a demonstrated track record of results;
- eliminate barriers to the scaling of those ventures; and
- officially recognize interventions that work.

Expanded learning time has significant promise and the state should work to scale expanded learning time initiatives with proven providers that focus on STEM education.

In addition, the state should empower and formalize the work of the Regional STEM Pipeline Networks to identify programs that work in their regions and bring those efforts to scale in some meaningful way, with particular focus on enhancing and supporting opportunities for girls and underrepresented youth.

In parallel, the state should provide support to models such as the National Girls Collaborative Project that seeks to promote coordination and collaboration among girl-serving STEM programs, higher education institutions and industry, to create programs whose design is based on evidence of success.

In all cases, funding and support should be based on the principle of equity, and investments should be made to create materials and programs that are multilingual, culturally sensitive and accessible to people with disabilities.

Strategic Priority 4: MENTORSHIP & ROLE MODELING

Through an evaluation of best practices for increasing interest in STEM fields, particularly among underrepresented minorities and women, it becomes clear that mentoring and role modeling will provide an opportunity to not only motivate youth but also provide them with much needed support in the long journey to achieving math and science proficiency – a prerequisite for any STEM-based university program – given the educational achievement gap faced by these groups. Studies show that 75% of all engineers today had at least one parent that was an engineer; but given the low incidence rate of underrepresented minority engineers, there is a need to supplement the encouragement that this demographic is receiving.

In 1997, ***Eyes to the Future***, a national mentoring program for middle school girls based in Cambridge, MA, reported that there was a wide gap in girls' rates of enrollment and achievement in science courses, in comparison with boys. This gender gap increased as students moved towards high-school, increasing from age 9 to age 13[xxix]. According to the ***Eyes to the Future*** findings, middle school is a decisive period in a girl's formation as a learner of math and science. Unfortunately, this gap still persists today. Equally discouraging is the fact that underrepresented minority groups in STEM are making even less progress. The 2008 National Action Council for Minorities in Engineering, Inc. (NACME) report ***"Confronting the 'New' American Dilemma: Underrepresented Minorities in Engineering: A Data-Based Look at Diversity***," suggests that members of all ethnic groups—except Asian/Pacific Islanders—were less likely in 2005 than in 1995 to earn bachelor's degrees in engineering. Except for Asian/Pacific Islanders, bachelor's degrees in engineering represented a very small proportion of all degrees awarded within each of the other four groups. Engineering schools have not yet been able to recruit enough students from groups other than non-Hispanic white males to account for the fact that there is a decline in this group's (i.e., non-Hispanic white males) overall representation in the college-age population.

Citizen Schools, as referenced on page 31, would likely agree with this finding. In their white paper entitled, ***"Citizen Schools Agenda for the 111th Congress,"*** the organization contends that our nation's ability to bring more caring adults into children's lives and assist schools in meeting their students' needs, quality after-school and expanded learning time programs, will depend on a talented and well-equipped workforce. Unfortunately, across the country, too many communities lack the resources needed to recruit, train, and support a committed "second shift" of instructors and mentors to work with students in some of our nation's neediest schools.

Structured mentoring programs can help mitigate these disparities and increase the number of girls and underrepresented minority students who are interested in STEM as well as their overall academic success and graduation rates. Why mentoring? One compelling reason is the fact that studies of middle- and high-school females suggest that engagement with mentors can significantly improve self-confidence with regard to math science and technology.[xxx] In addition, in a recent study of ***Big Brothers Big Sisters' School-Based Mentoring (SBM)*** programs,

Hispanic Students and the STEM Pipeline

The Hispanic population in the United States has been growing at dramatic rates over the past few decades. From 2000 to 2006 alone, Hispanics accounted for one half of the nation's growth. In the Northeast the percent change of the Hispanic population was 15.1% as compared to the total population growth of 2.0%. Of individual school districts throughout Massachusetts with the highest percentage of Hispanics, about 55% are clustered within the cities with the highest percentage of families living below the poverty level.

Of the groups interested in STEM careers, data indicates that high performing minority/women students in low-performing school districts have a higher percentage of interest than other groups (not including Asian students). These districts are mostly located in the higher density inner cities where the majority of the student population is either Hispanic or African-American. STEM careers should be promoted by offering such initiatives as STEM clubs, STEM Summer camps and mentoring programs with Hispanic role models. The Hispanic culture has unique and specific characteristics that call for new and creative solutions when it comes to best practices in education. The same is true of any effort to create interest in future careers in the STEM fields. For example, Hispanics are very social and family-oriented. To reach the children, we have to reach their parents, extended family and the community. One way to do so is to promote STEM initiatives through highly visible events and through advertising in media outlets readily accessed by the Hispanic community. Such efforts will ultimately reach the students who will benefit the greatest.

The Hispanic culture cannot be viewed as a single group since it is composed with individuals from many distinct and unique countries. Although this group speaks the same language, their geographical origin, specific cultural background and history defines each and every sub-group's relevant characteristics. There are many limiting factors that cause Hispanic children in Massachusetts to have the highest high school dropout rate in the state. The language component is one of the most obvious limiting factors. In addition, the socio-economic condition of this group as a whole creates many compounding factors that limit these children from accessing the resources needed to effectively and successfully be educated in the current educational system. Additional education supports, exposure to Hispanic college students and adults engaged in these fields will help encourage more Hispanic young people to enter the pipeline.

"Making a Difference in Schools: the Big Brothers Big Sisters School-Based Mentoring Impact Study," [xxxi] researchers found that mentoring had a substantial impact on student success (grades four through nine) in a relatively short amount of time (as little as six months). In fact, by the end of the first school year, the BBBS school-based mentoring program had improved mentees outcomes in a range of areas including their academic attitudes, performance, and behaviors. The report goes on to say that, on average, given the typical delays in starting programs at the beginning of the school year, mentees "...received only slightly more than five months of SBM during their first school year of participation."

So, despite the short time frame, teachers still reported that, relative to their non-mentored peers, mentees showed improvements in the following outcomes: "Overall academic performance, as well as in the specific subjects of science, and written and oral language; quality of class work; number of assignments turned in (homework and in-class assignments); and serious school infractions (including principal's office visits, fighting and suspensions). They also improved in the following youth-reported outcomes: scholastic efficacy (feeling more competent academically); and skipping school—which teachers confirmed by reporting that fewer mentees had an unexcused absence in the four weeks prior to the survey." These are particularly interesting findings given that the schools targeted for this study were in low-income areas and were facing challenges in meeting academic performance standards. Results from the BBBS study suggest that network-supported mentorship programs can provide important content and motivation in STEM for all students, particularly girls and underrepresented minorities.

It is increasingly clear that our nation's future depends on the existence of a strong higher education system that provides learning opportunities at every level and throughout life. As educators and citizens, we have an awesome responsibility to prepare students to be full

participants in the global society. Projections continue to indicate that many institutions of higher education will have a student pool that is more diverse across virtually every demographic category. Mentoring programs can be one of the most effective tools used by schools to heighten the level of consciousness in working with diverse students and promoting retention. That said, it is equally important to recognize that although mentoring and role modeling are effective tools, they have to be implemented properly in order to maximize the return. Adversely, a poorly designed mentoring program can have detrimental results.

Therefore, mentoring and role-modeling engagement should be part of a systemic process that is both consistent and culturally relevant. Although a one-time experience can at times be sufficient to provoke change, it is often the exposure to a message being repeated over and over that is internalized. This repetition is particularly necessary in the case of many inner city youths since their life experiences have made them skeptical of the opportunities that are available. In order for a mind shift to occur, mentors need to build personal relationships with students and demonstrate to them that they are committed to the youth's success. Once the bond of trust is established, then deeper discussions about the STEM opportunity should take place. The delivery of a clear STEM message, including the importance of being prepared to seize the opportunity created by the STEM pipeline shortage as well as the excitement and financial rewards associated with these careers, should be conveyed not only in a classroom setting (e.g., school-based mentoring programs) but also via multi-disciplinary approaches in partnership with mentors such as team based competitions, summer STEM camps, internships, as well as job shadow days.

The importance of having culturally relevant messaging has been widely acknowledged and incorporated into marketing and advertisement campaigns for decades within "corporate America." However, relationships between mentors and mentees are much closer and intimate than that of most suppliers and their customers; yet, in general, mentoring programs fail to incorporate a cultural competency component. One could argue that the need for cultural alignment is heightened in mentorship and role-modeling scenarios and that when that alignment is achieved, the bonds of trust are quickly established thus facilitating open communication and an increased willingness to accept guidance on the part of the mentee. Moreover, with a deep cultural understanding of both the challenges and advantages that a given belief system may incorporate, a mentor is better positioned to strategize on the best ways to motivate a mentee, can better understand the severity of each roadblock a mentee may encounter (such as the expectation by certain cultures that youth go to work once they graduate HS), and also, from a mentee's perspective, offer a "realistic" view of what the mentee can achieve through hard work and perseverance.

The STEM pipeline shortage is one of the greatest challenges the United States will face in the current generation and further enflaming the issue is the fact that our fastest growing populations are also the ones suffering from the greatest achievement gaps. Without a cadre of mentors and role models to inspire these youth to believe in themselves and help them understand the vast opportunity that this perfect (STEM) storm brings to the table, we will be unable to compete in the global economy in years to come. Therefore, mentors and role models should be a critical and

integral component of any initiative that aims to positively influence youth to consider and pursue STEM careers.

BEST PRACTICES

For Inspiration and Recognition of Science and Technology (FIRST) Robotics.

- **Grade levels reached** - High school students
- **Type of program** - After-school program
- **Typical audience** - All students. More effort could probably be put into getting girls and minorities into the program; however, the infrastructure for doing this already exists.
- **Commitment duration** - Varies. Building of the robot is a six to eight week long project, but communities have essentially turned the entire process into a year-long commitment. Communities rally around fund raising efforts, starting FIRST Lego League programs at the middle school level, and celebrating the students who are involved in the program.
- **Scalability** - FIRST has hundreds of programs running all around the world. The number of teams appears to be growing yearly. Because numerous universities have offered scholarships to students participating in FIRST, and data supports that students participating in FIRST have a greater likelihood of entering STEM fields, it is a program which has shown that participation correlates to continuation of a career in STEM.
- **Why FIRST is unique** - FIRST is unique because it creates an environment where STEM becomes "cool." The FIRST events are like "sporting" events. There are elements of competition, teamwork building and the involvement of entire communities in the effort of "the team." It is quite effective and unique in that it really mobilizes a large number of people to stand behind and support a team.
- **Quantification of success** - As mentioned previously, a large number of students who participate in the program enter universities and pursue STEM fields. The list of universities and colleges willing to offer scholarships to those involved in the program is lengthy. This would substantiate the claim that participating in FIRST increases the likelihood that the student will pursue a career in a STEM field.
- **Downside** - It is costly. Each robot building kit costs around $10,000-$15,000. Teams typically must seek sponsorship and participate in fundraising events. Also, the program essentially requires adult involvement. With this in mind, the reality is that in forcing parents and mentors to play a more active role, the likelihood of parental and external support increases.

MIT Saturday Engineering Enrichment and Discovery Academy (SEED) Program

- **Grade levels reached** - Boston Area high school students
- **Type of program** - Program takes place on Saturdays
- **Typical audience** - This program is specifically oriented for minority students. Students fill out applications and are "admitted" to this competitive program.

- **Commitment duration** - Varies. The goal of the program is to retain students for the full four years of high school. The program takes place every Saturday for several hours.
- **Scalability** - SEED is currently a program running exclusively out of MIT. Students are taught STEM related material over the course of seven semesters. They create projects that are displayed during special events. At the end of seven semesters, there is a graduation ceremony celebrating the successful completion of the program. Because the program is competitive, students understand the value of being involved. The program also pays special attention to getting parents and mentors involved. After the four years, those who are still dedicated are asked to return to be involved in the program. Of the students who start, approximately 80% of the students stay in the program for the entire duration.
- **Why SEED is unique** - SEED is unique because students that sign up commit to being a part of the program for seven semesters. This makes the program intensive and long lasting. It is not a "one hit wonder." The retention numbers are very high, which indicates that the students are enjoying what they are learning.
- **Quantification of success** - SEED has a high retention of its students. Also, the number of students that continued onto college was significantly higher than the average for the particular demographic the program served.
- **Downside** - It is currently running only in Boston. Because it is run out of MIT, many of the resources are tied to MIT. It is possible to scale the program in other places; an infrastructure similar to the one at MIT (which provides a place for students to meet, and knowledgeable mentors) would need to be implemented.

Citizen Schools

- **Grade levels reached** - Middle school students (6^{th}-8^{th} grade)
- **Type of program** - After-school program
- **Typical audience** - All students with emphasis on underrepresented minorities.
- **Commitment duration** - Year-long. Mentors who sign up to participate in the program are involved for 11-weeks.
- **Scalability** - Citizen Schools is currently running in a number of different states. Thus, they have shown that they are scalable already. Since, it is possible to recruit volunteer mentors anywhere, the model should be scalable.
- **Why Citizen Schools is unique** - Citizen Schools is unique because it is an after school program that pairs a mentor with a student. The mentors help to teach the student about a specific topic the student is interested in. It is a multi-session program, meaning that the students see the mentor 11 times over the course of a year. Citizen teachers come to the school to allow easier accessibility for the middle school students. The students get personalized attention from the mentors. The program focuses on STEM, and supports skill development intended to promote the achievement of long term academic, social, career and civic success and it teaches students the importance of continuing their educations by completing high school and entering college.

- **Quantification of success** - They have hired external evaluators to assess whether students in the program have a higher likelihood of going to college and are able to get better grades in high school.
- **Downside** - The ratio of students to teachers is very low. There are 4,000 students who have been served by the program and there are 4,000 volunteer teachers. This is only a 1 to 1 ratio, so there is a need for a large number of volunteers to keep the program running successfully. Not all students will have an opportunity to be mentored because of this ratio. There does not appear to be a set structured curriculum since each program is tailored by the mentor and mentee. This program is not exclusively STEM oriented, so the number of volunteers who are STEM oriented is going to be less than their overall total numbers. STEM is not their specific focus. The program charges $900 per student.

Science From Scientists (Formerly known as WhizKids)

- **Grade levels reached**- 4th through 8th
- **Type of program**- In school hands-on curriculum-based science/math enrichment program
- **Typical audience** - This program is oriented to all 4th-8th grade students. Due to the diversity of the staff and the audience, a crucial part of the program is the relationship that develops between Science From Scientists staff and the students they teach. Students have an opportunity to interact with staff members and learn about careers in the fields of STEM.
- **Commitment duration** - Science From Scientists commits to each school for one year, approximately 20-22 visits, plus one field trip.
- **Scalability** - Science From Scientists is typically operated in between 15 and 20 schools per year. Over the course of the last four years Science From Scientists have worked with approximately 4,000 students. The scalability of the program is contingent upon the number of scientists hired to teach in the program and the number of schools interested in the program. Science From Scientists is currently running only in Massachusetts.
- **Why Science From Scientists is unique**- Science From Scientists is a during school program that complements in-school curricula. Science From Scientists works with schools to make normal learning material more relevant and exciting. Science From Scientists sends actual scientists into the schools. In order to teach for Science From Scientists, individuals must have an undergraduate degree in a math, science or engineering field and be actively enrolled in an advanced degree program (PhD, MD, MS or DMD). Science From Scientists visits each classroom 20-22 times per year and all lesson plans developed by Science From Scientists help the students prepare for the MCAS exam. Finally, the program is currently free of cost to the schools involved.
- **Quantification of success**- Science From Scientists administers pre- and post-exams to quantify how much of the material was absorbed by the students. Science From Scientists

also administers surveys filled out by school personnel and students assessing the performance of instructors and the relevance of the material to the school curricula.

- **Downside** - Assessment of students' progress over time is immature. Qualitative testimonials from participating schools are encouraging, but the program would benefit from external analysis of improvements in quantifiable STEM skills and interest.

RECOMMENDATIONS

The STEM Advisory Council needs to create a statewide strategy that incorporates best practice principles for mentorship, such as consistency of message and intensity of engagement. The outreach should be done in partnership with community organizations committed to the success of our youth, such as the existing programs outlined above as well as others in development that show promise (i.e. Latino STEM Alliance and others). Moreover, above and beyond this statewide effort, specialized programs should be funded to cater to the particular needs of underrepresented minorities - and female - students in a manner that is cognizant of the cultural propensities of these groups. Mentorship programs that do not have a cultural relevancy component will have limited impact, particularly within underrepresented minority communities, as evidenced by the fact that although there are many successful initiatives currently in place throughout Massachusetts, participation by underrepresented minority groups in these activities, and consequently STEM graduates originating from these groups, is not representative of the state's demographic breakdown. Incidentally, the story is no different nationally where our largest and fastest growing underrepresentative minority group, Latinos, currently account for approximately 6% of all STEM graduates at the bachelor's level, 1% at the master's level, and 2% at the doctoral level.[xxxii]

Additionally, it is suggested that the state's strategy be a multifaceted one that recognizes that a single-pronged approach is insufficient. The STEM pipeline issue needs to be attacked in the classroom, in extracurricular settings, as well as at home. Similar to a three-legged stool that falters when one leg is damaged, each supporting program must do its part to ensure balance and strength as they collectively bear the brute force of years of negative media depictions of STEM professionals, peer pressure from those that are unable to meet the rigor of STEM educational programs, as well as the irrefutable proficiency deficits that many students will face even when their interest is high and best intentions are at hand. It is here, under immense pressure, that mentors will deliver their greatest contributions for it is from these role models that students will draw the drive to overcome conditions of economic disparity, cultural differences and gender stereotypes.

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